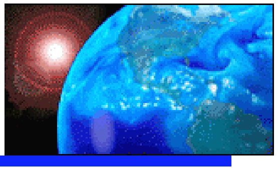

Information Systems for the Earth Science 2025 Vision

Technology Steering Team Briefing

at Glenn Research Center

September 18, 2000

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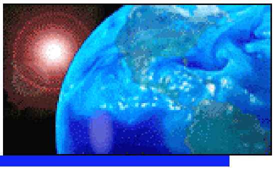
2025 Vision Brief. . .

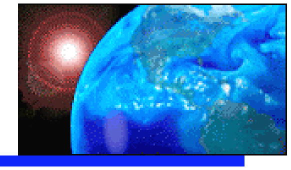
- **Two companion documents with this presentation:**
  - Earth Science Vision Workshop #1 Summary of Science Goals and Capability Challenges.
  - Earth Science Vision Workshop #1 & #2 Summary of Technologies.

2025 Vision Brief. . .



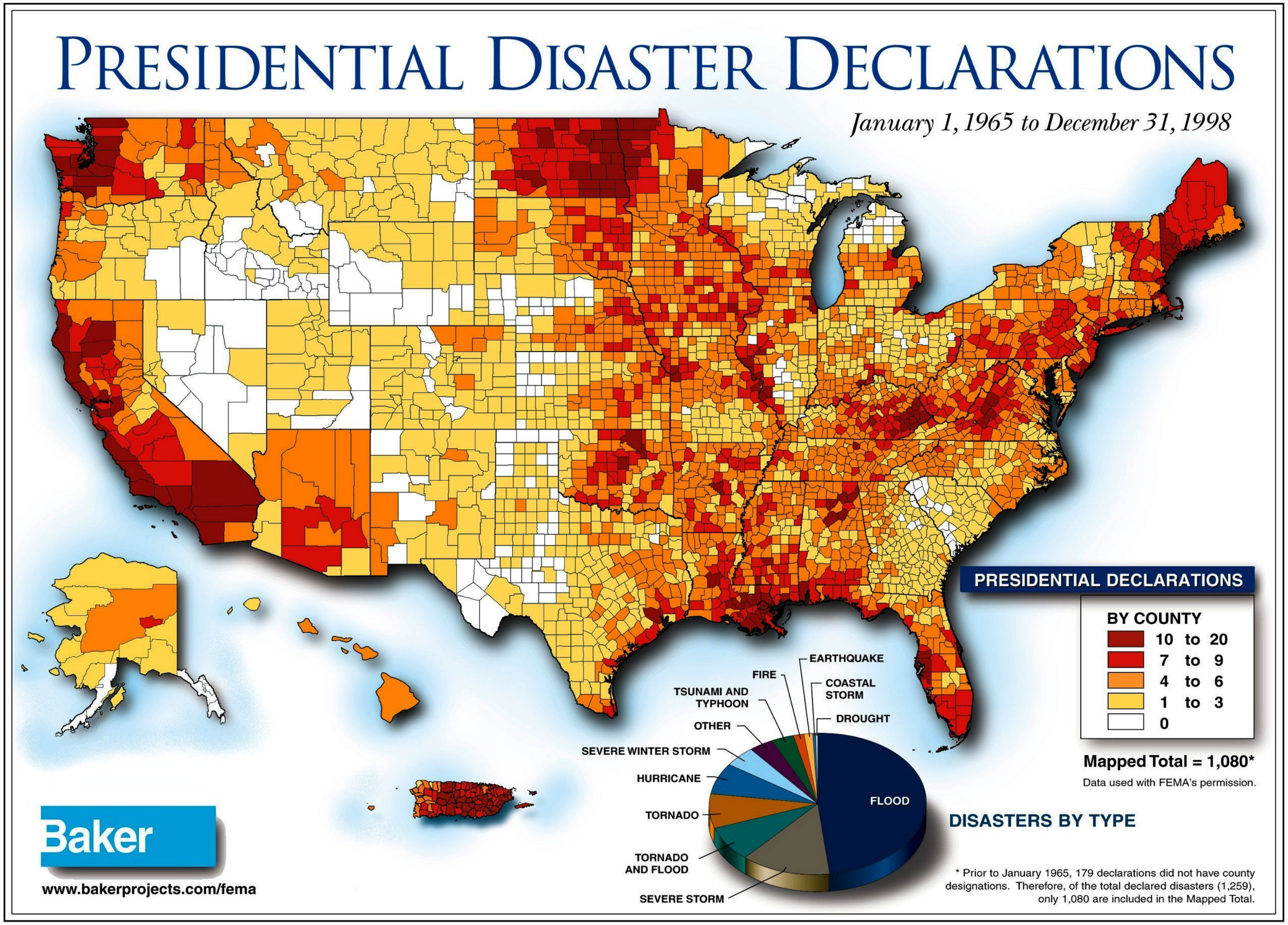
- **Outline**
  - Predictive capabilities are a crucial element of the Vision.
  - Envisioned capabilities “define” requirements for IS technologies.
  - Some “practical” implications of these requirements.
  - Conclusions that can be made.

Predictive Capabilities = Paramount Value

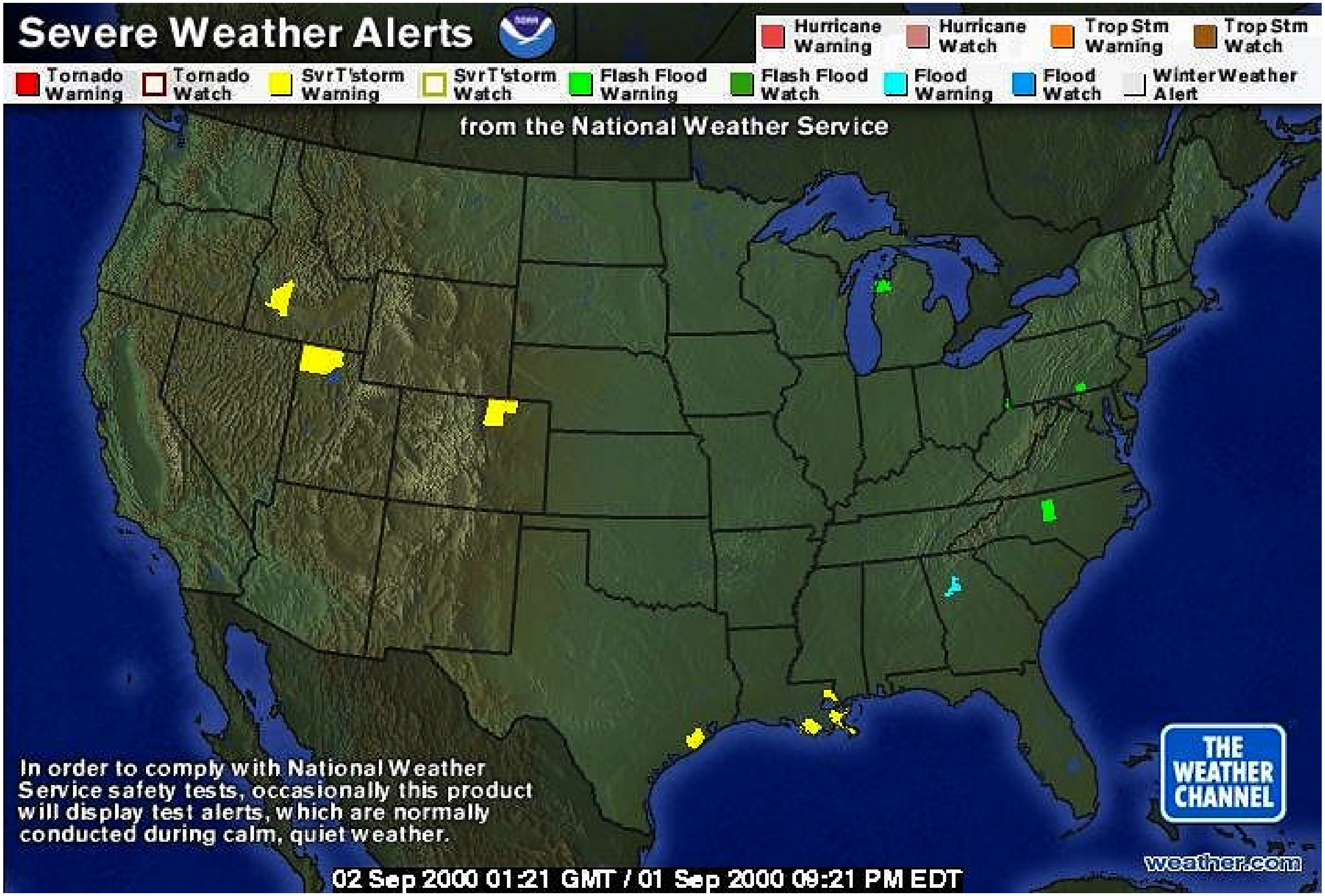


- **A primary driver for the 2025 Vision is “Economic Benefits to the Nation”.**
- **Predictive capabilities provide maximum return-on-investment to the public, industry, and to Federal; State; and Local Governments.**
  - Weather and Climate
    - Temperature, Precipitation, Clouds, Humidity, Winds, etc...
  - Natural Hazards
    - Hurricanes, Tornadoes, Floods, Droughts, Earthquakes, Volcanoes, Thunder Storms, Winter Storms, Tropical Storms, and Forest Fires.

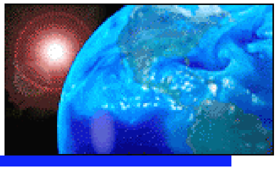
Impact of Natural Hazards



Present Short-term Hazard Predictions

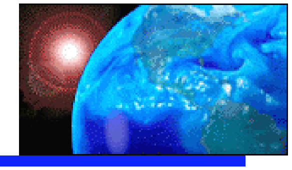


Predictive Capabilities for 2025



- **The vision evokes advanced predictive capabilities in the following areas:**
  - Weather
    - Extending the useful range (~ weeks) of short-term predictions.
  - Climate
    - Improving accuracy of near-term (~ months) predictions.
    - Developing long-term (~ years) predictions.
  - Natural Hazards
    - Experimental forecasting of hazard warnings.
    - Experimental forecasting of long- and mid-term predictions for certain events.

Advances in Weather Predictability



2000

- 3-Day forecast at 78%
- 7 Day forecast not achievable
- 3 day rainfall forecast not achievable
- Hurricane landfall +/-400Km at 2-3 days
- Air quality day by day

2010

- 3-Day forecast at >90%
- 7-10 Day forecast at 75%
- 3 day rainfall forecast routine
- Hurricane landfall +/-100Km at 2-3 days
- Air quality forecast at 2 days

2025

- 7-10 Day forecast at >90%
- 14 Day forecast possible
- 7 day rainfall forecast routine
- Hurrica ne landfall +/-30Km at 5 days
- Air quality forecast at 7-10 days

Advances in Climate Predictability

2000

- 6-12 month seasonal prediction experimental; achieved an understanding of El Nino mechanics
- Decadal climate prediction with coarse models and significant uncertainties in forcing and response factors

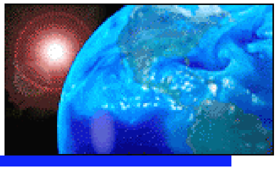
2010

- 6-12 month seasonal prediction routine; 12-24 months experimental
- 10 year climate forecasts experimental; moderate to high confidence in forcing & response factors

2025

- 15-20 month El Nino prediction
- 12 month rainfall rate forecast
- 10 year climate forecasts with 90% confidence; 50 year climate forecasts

Advances in Natural Hazards Predictability



2000	2010	2025
• Demonstrate centimeter-level measurement of land deformation • Accurate characterization of long-term tectonic motions, but no short-term earthquake forecast capability • Accurate characterization of volcanic activity, but no long-term prediction accuracy	• Continuous monitoring of surface deformation in vulnerable regions with millimeter accuracy • Improved temporal dimension of earthquake & volcanic eruption forecasts • Improve post-eruption hazard assessment	• 60-day volcano prediction - experimental • 1-5 year earthquake forecasts - experimental • Understand the state of stress and structure of the Earth's crust leading to earthquakes & volcanoes

Predictive Capabilities "Push" IS

What do these envisioned capabilities require from Information Systems?

“Push” Requirements for IS

- Predictive capabilities deliver real-time products directly to the users.
- Natural Hazard and Weather observing systems are self-tasking (driven by seasonal or event triggers).
- SensorWebs provide new complex data sets needed by coupled modeling networks (e.g., different spatial and temporal resolutions, revisit rates, and new data types).

"Push" Requirements for IS. . .

- Different data products are generated using the same infrastructure.
- Ability to automatically seek, retrieve, and process various data types needed to support autonomously-tasked processing modes.

Challenges for IS in 2025

What technical areas do these requirements "push". . . and what does the push imply?

Implications of these Requirements

- **Predictive capabilities deliver near real-time products directly to the public.**
  - IS architectures implement seamless end-to-end data systems.
  - Number-crunching modules (e.g., data calibration and modeling) are implemented as ***inline real-time transfer functions***.
  - Near-term modeling engines have no “initial” or “end” computational states, but rather a “computational continuum”.
  - Visualization layers are the primary user-interface system.
  - Distribution networks provide direct delivery to users.

Implications of these Requirements. . .

- **Natural Hazard and Weather monitoring systems are self-tasking (driven by seasonal or event triggers).**
    - ISs provide a consolidated communications backbone (science + engineering + operations) that enable real-time management of the operational “state” of complex predictive systems.
    - ISs provide control interfaces that enable reconfiguration through “dynamic resource binding” of orbiting sensors, ground data sources, data processing pipelines, visualization layers, and distribution networks.

Implications of these Requirements. . .

- **Sensorwebs provide new complex data sets needed by coupled modeling networks (e.g., different spatial and temporal resolutions, revisit rates, and new and old data formats).**
  - Distributed spacecraft algorithms help coordinate the multi-platform architectures that provide these data.
  - Modeling networks and nodes have “operating modes” and are managed just as spacecraft assets are now.
  - Data formats allow observational “context” to be embedded into measurement sets (somewhat analogous to what ***software objects*** do now).
  - New Models, Control algorithms, and Data Processing algorithms can ingest and correctly process these “enriched” data formats.

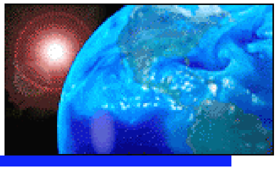
Implications of these Requirements. . .

- **Different user products are generated using the same infrastructure.**
  - Interactions among different types of space and ground systems and “resources” are handled transparently.
  - ISs provide pathways, communication protocols, and “smart agents” needed to monitor and control the “state” of these systems-of-systems.
  - ISs provide data gateways and pipelines that support event-driven DATA FLOW RECONFIGURATIONS needed by different “observing states”.
  - ISs provide “smart agents” needed to manage access to shared resources.

Implications of these Requirements. . .

- **Ability to automatically seek, retrieve, and process various data types that support autonomously-tasked observation modes.**
  - Everything is ON-LINE and may be accessed quickly. Online libraries provide real-time access to stored data sets, terrain maps, historical records, and knowledge databases.
  - ISs provide interfaces and context-aware "smart agents" that locate and tap various data resources.

Conclusions



- **The vision's *Predictive Capabilities* arena presents IS challenges that demand REVOLUTIONARY solutions. Work on some of these challenges should start NOW!**

- **Development of new IS building-blocks for SensorWebs, Distributed Spacecraft Management suites, Modeling Engines, and Data Bases has to be concurrent and collaborative.**

- **The infrastructure (processors, protocols, and pipelines) that IS must provide to build new systems-of-systems has to evolve guided by a unified set of "interoperability specs".**